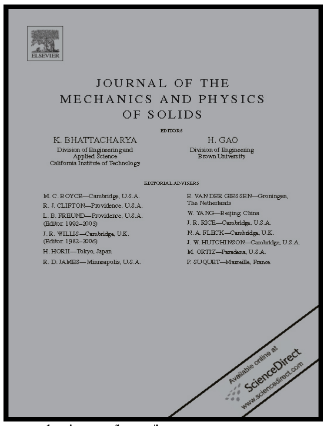
Author's Accepted Manuscript



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PII: S0022-5096(15)30007-7
DOI: http://dx.doi.org/10.1016/j.jmps.2015.07.002
Reference: MPS2680

To appear in: *Journal of the Mechanics and Physics of Solids*

Received date: 26 March 2014
Revised date: 25 June 2015
Accepted date: 1 July 2015

Cite this article as: D.D. Tjahjanto, O. Girlanda and S. Östlund, Anisotropic viscoelastic–viscoplastic continuum model for high-density cellulose-based materials, *Journal of the Mechanics and Physics of Solids,* http://dx.doi.org/10.1016/j.jmps.2015.07.002

Anisotropic viscoelastic–viscoplastic continuum model for high-density cellulose-based materials

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Abstract

A continuum material model is developed for simulating the mechanical response of high-density cellulose-based materials subjected to stationary and transient loading. The model is formulated in an infinitesimal strain framework, where the total strain is decomposed into elastic and plastic parts. The model adopts a standard linear viscoelastic solid model expressed in terms of Boltzmann hereditary integral form, which is coupled to a rate-dependent viscoplastic formulation to describe the irreversible plastic part of the overall strain. An anisotropic hardening law with a kinematic effect is particularly adopted in order to capture the complex stress–strain hysteresis typically observed in polymeric materials. In addition, the present model accounts for the effects of material densification associated with through-thickness compression, which are captured using an exponential law typically applied in the continuum description of elasticity in porous media.

Material parameters used in the present model are calibrated to the experimental data for high-density (press)boards. The experimental characterization procedures as well as the calibration of the parameters are highlighted. The results of the model simulations are systematically analyzed and validated against the corresponding experimental data. The comparisons show that the predictions of the present model are in very good agreement with the experimental observations for both stationary and transient load cases.

Keywords: Cellulose-based materials, Viscoelasticity, Viscoplasticity, Anisotropic–kinematic hardening, Material densification, Creep, Stress relaxation